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'LOW-GOLD' CROWN-AND-BRIDGE ALLOYS,(U)

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(10) Eugene F. Huget [redacted] Stanley G. Vermilyea, LTC
[redacted] Jesus M. Vilca, ~~SP/5~~

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Composition, microstructure, mechanical properties and heat treatment characteristics of three low-gold dental casting alloys were studied. The materials exhibited vast compositional differences but strikingly similar structural features.

Overall, the laboratory properties of the test materials suggest their potential usefulness for the production of fixed dental prostheses.

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"LOW-GOLD" CROWN-AND-BRIDGE ALLOYS

COL Eugene F. Huget*
LTC Stanley G. Vermilyea+
SP/5 Jesus M. Vilca#

U.S. Army Institute of Dental Research
Division of Dental Materials
Washington, D.C. 20012

Commercial materials and equipment are identified in this report to specify the experimental procedure. Such identification does not imply official recommendation or endorsement or that the equipment and materials are necessarily the best available for the purpose.

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* Chief, Division of Dental Materials
+ Research Dental Officer
# Physical Scientist

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"LOW-GOLD" CROWN-AND-BRIDGE ALLOYS

Relentless escalation of the cost of gold and other noble metals has necessitated consideration of the use of so-called low-gold alloys for the fabrication of fixed dental prostheses (crowns and bridges). Studies have been undertaken at the United States Army Institute of Dental Research to evaluate the suitability of a number of these materials for routine military application. The present work assessed composition, microstructure, mechanical properties and heat-treatment characteristics of three alternatives to conventional type III dental casting gold.

Materials and Methods

Test alloys marketed under trade names of Midas[*], Neycast[+], and Minigold[#] were obtained from proprietary sources. Composition of randomly selected ingots of each material was estimated by atomic absorption spectrophotometry.[§]

Wax patterns for the fabrication of hardness, metallographic and tensile specimens were invested in a phosphate bonded refractory material.[¶]

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* J. F. Jelenko and Company, Pennwalt Corp., Armonk, N.Y.

\+ The J. M. Ney Co., Bloomfield, Conn.

\# Williams Gold Refining Co., Buffalo, N.Y.

§ Spectrophotometer, model 403, Perkin-Elmer Corp., Norwalk, Conn.

¶ Ceramigold Investment, Whip-Mix Corp., Louisville, Ky.

The molds were heated in a gas oven from room temperature to 1,350°F and held at temperature for 45 min to insure complete elimination of the wax. The alloys were melted with the use of a gas-air torch and cast by means of a conventional broken arm casting machine. The cast molds were bench cooled to room temperature prior to retrieval of the test pieces.

Specimens for determination of hardness and microstructure were 14 X 0.5-mm disks. A face of each casting was polished sequentially with 240 to 600 grit abrasive papers, 6.0-μm diamond paste and 0.05-μm alumina. Metallographic specimens were etched thermally and examined on a hotstage metallurgical microscope.[Ω] Vickers (DPN) hardness values of plastic-mounted disks were obtained through the use of a testing machine[**] and a 136-degree square-base diamond pyramid indenter.

Upon measurement of as-cast hardness, the cast pieces were removed from their mounts, heat treated, remounted and repolished for further testing. Annealing temperature ranges of the alloys were established by monitoring changes in the hardness of castings subjected to seven successive ten-min heat treatments at 200 degree intervals from 400°F to 1,600°F. All heat treatments were terminated by immediate immersion of the cast pieces in room temperature water. Hardness was measured after quenching of the specimens from each treatment temperature. Hardening temperature ranges were revealed by serial reheat treatment of previously annealed disks over the 400°F to 1,600°F temperature range.

Ω Unitron, model BN-11, Unitron Instrument Co., Newton Highlands, Mass.

** Kentrall Hardness Tester Model MC-1, Riehle Testing Machines, East Moline, Ill.

Again, hardness was measured after a ten-min exposure of each casting to each of seven treatment temperatures.

Tensile properties of as-cast and annealed pieces that conformed to the dimensions prescribed by American Dental Association Specification No. 14 for dental chromium-cobalt casting alloy[1] were determined on a constant strain testing machine[++] at a crosshead speed of 0.02 in per min.

Results

Estimated compositions of the alloys are given in Table 1. Midas, Neycast and Minigold were based on systems of gold-silver, gold-copper and silver-gold, respectively. Palladium was a minor component of all three materials. Indium was a trace constituent of Minigold.

Structural features of the test materials are presented in Figure 1. Exposure of metallographic specimens to a temperature of 1,200°F for a period of 30 min was sufficient to reveal grain boundaries. Significant differences in grain morphology and grain size were not detected.

Responses of the as-cast alloys to heat treatment are shown in Figure 2. Progressive reduction of hardness was a salient feature of specimens quenched from 1,000°F and 1,200°F. Hardness values for castings subjected to treatment at 1,200°F exhibited total reduction in hardness of about 36 percent (Midas), 18 percent (Neycast) and 33 percent (Minigold), respectively. Continued heat treatment at temperatures in excess of 1,200°F did not elicit further softening.

++ Instron Universal Testing Machine, Instron Engineering Corp., Canton, Mass.

Responses of annealed cast disks to reheat treatment are illustrated in Figure 3. Maximum hardness of all three alloys was attained with a ten-min reheat treatment at 800°F.

Tensile properties are summarized in Table 2. As-cast strength, rigidity and ductility of the test products were strikingly similar. Specimens quenched from 1,200°F exhibited significantly lower strength and greater plastic deformation (ductility) than their as-cast counterparts.

Discussion

The findings indicate that the structural features and mechanical properties of the low-gold alloys remain remarkably constant over a broad range of compositions. Also, it is noteworthy that the responses of the low carat materials to aging and annealing heat treamtents are comparable to those of alloys of simpler composition and higher gold content.[2]

Age hardening of the low-golds is attributed mainly to transformation of a gold-copper solid solution (stable at temperatures >800°F) to a more ordered gold-copper intermetallic compound (presumably $Au\ Cu_3$). From a practical point of view, the manipulative features of these alloys can be enhanced by solution heat treatment which reduces hardness and strength and increases ductility. Conversely, aging treatments at temperatures less than 800°F can be used to restore strength and hardness of previously annealed structures to insure satisfactory mechanical performance. Midas, Neycast and Minigold exhibit laboratory properties that suggest their potential usefulness for the production of fixed dental prostheses. Presently, however, the long-term *in vivo* serviceability

of alloys of low nobility remains uncertain. A clinical study designed to clarify this matter has been initiated.

Summary

Composition, microstructure, mechanical properties and heat treatment characteristics of three low-gold dental casting alloys were studied. The materials exhibited vast compositional differences but strikingly similar structural features.

Overall, the laboratory properties of the test materials suggest their potential usefulness for the production of fixed dental prostheses.

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TABLE 1

ALLOY COMPOSITION

	Midas %	Neycast %	Minigold %
Au	46.5	41.4	40.0
Ag	39.1	9.1	46.8
Pd	5.9	8.2	3.8
Cu	7.7	38.7	7.8
In	0.0	0.0	0.6

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TABLE 2

TENSILE PROPERTIES OF LOW-GOLD DENTAL ALLOYS

Alloy	Ultimate Tensile Strength $X10^3$ psi	Yield Strength 0.2% Offset $X10^3$ psi	Elastic Limit $X10^3$ psi	Young's Modulus $X10^6$ psi	Elongation %
Midas					
As-Cast	106±1	81±2	52±2	15±1	8±2
Annealed*	73±3	42±1	34±2	15±1	31±3
Neycast					
As-Cast	105±7	73±5	57±3	18±2	14±3
Annealed*	79±5	51±3	40±2	17±2	35±5
Minigold					
As-Cast	95±5	74±4	52±2	14±1	10±0
Annealed*	56±2	33±1	26±2	13±1	27±4

* 10 min at 1,200°F and water quenched.

D

Reference

1. Guide to Dental Materials and Devices, 6th ed., Chicago, Am. Dental Assoc., 1972-1973, pp. 207-209.
2. Guide to Dental Materials and Devices, 8th ed., Am. Dental Assoc. 1976-1978, pp. 117-118.

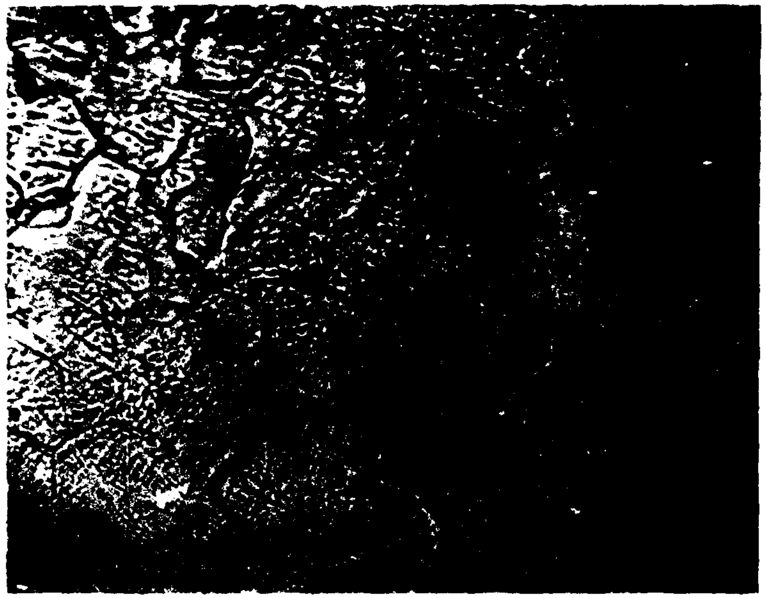
A

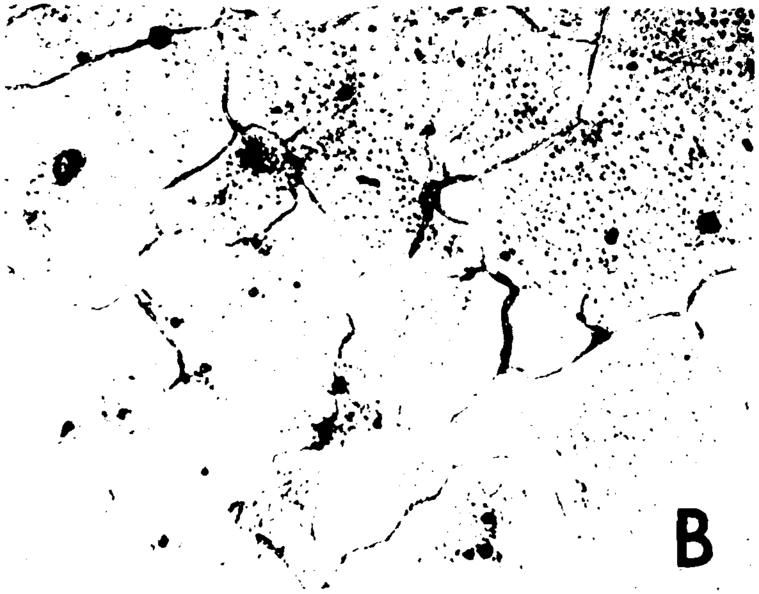
Legends for Figures

Figure 1. Microstructures of three low-gold alloys. A, Midas; B, Neycast; C, Minigold.

Figure 2. Response of three low-gold alloys to annealing heat treatments.

Figure 3. Response of three low-gold alloys to aging heat treatments.





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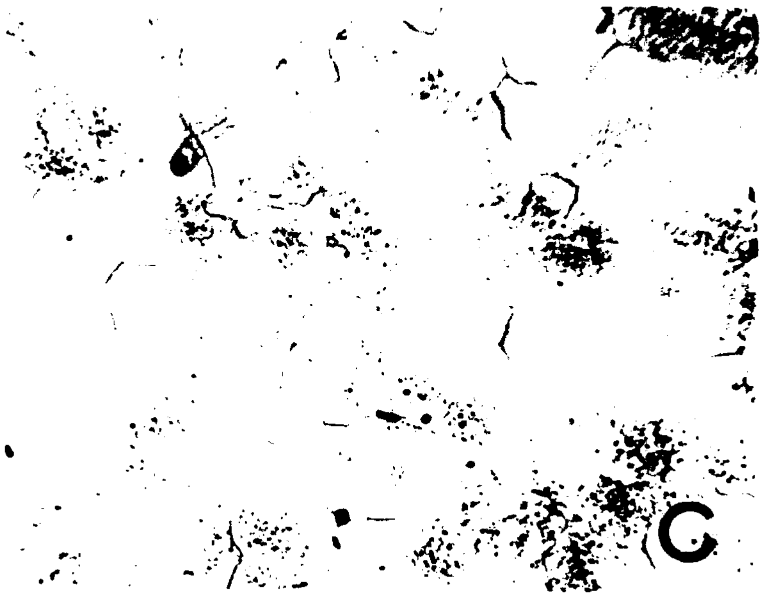

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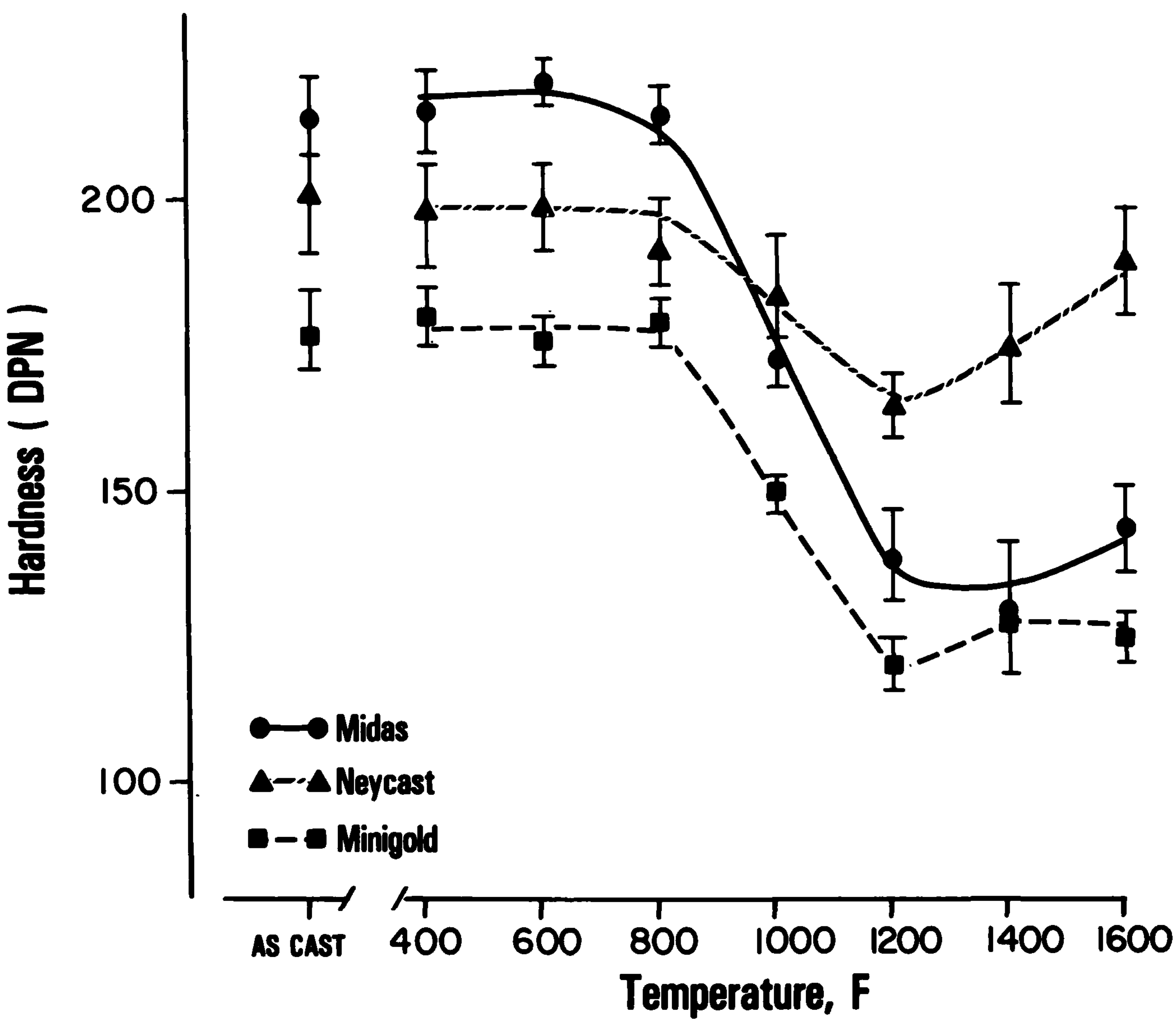
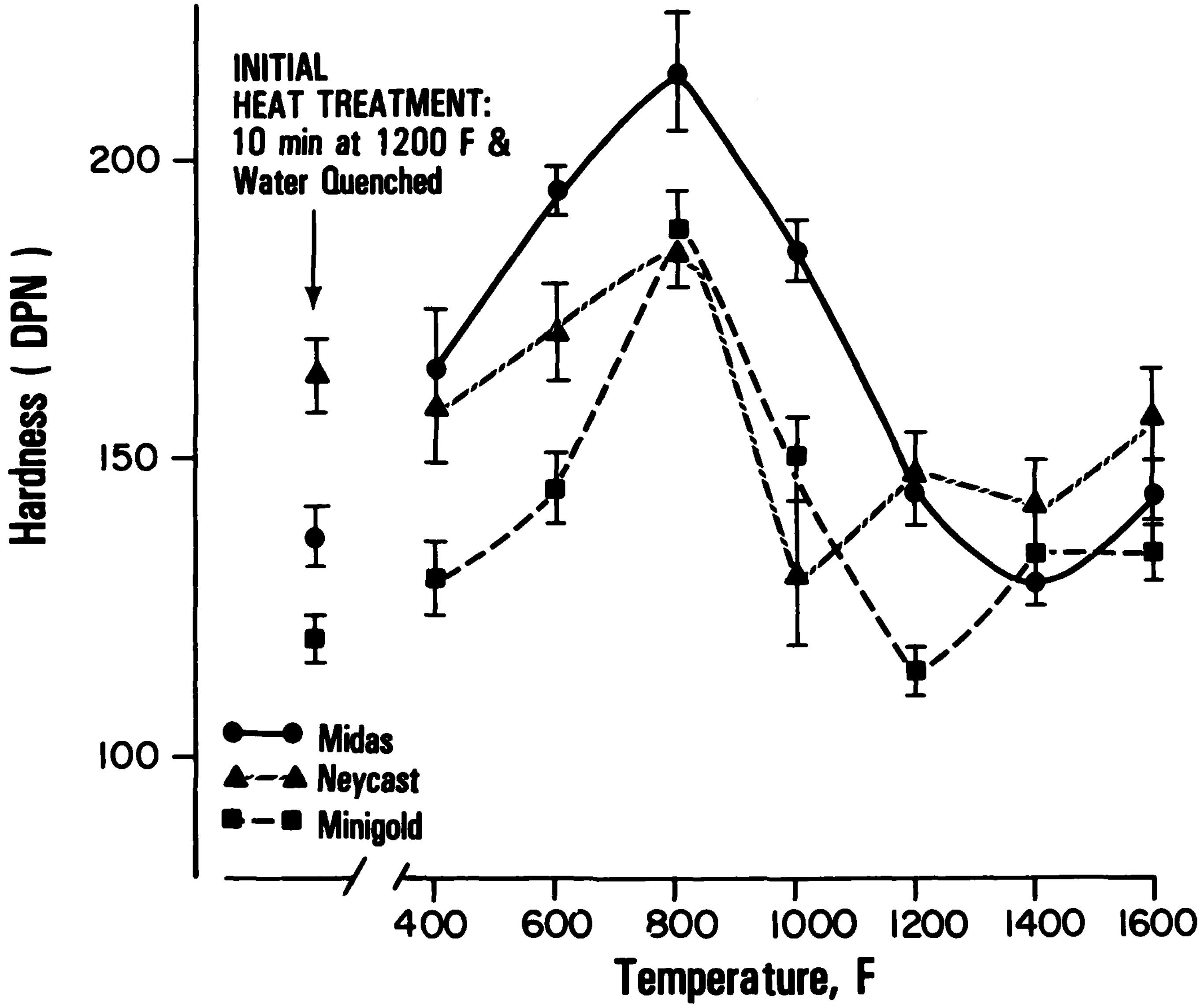

Hardness (DPN)
200
150
100
Midas
Neycast
Minigold
AS CAST
400
600
800
1000
1200
1400
1600
Temperature, F


INITIAL
HEAT TREATMENT:
10 min at 1200 F &
Water Quenched
Hardness (DPN)
200
150
100
Midas
Neycast
Minigold
400
600
800
1000
1200
1400
1600
Temperature, F